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tribution of trees in that region were a fruitful and congenial soil and a favorable climate. If the fires had never been introduced, the two first-named obstacles to forest-distribution in the prairie region would probably have been practically overcome by the time when the country was first settled; but, upon their introduction, an equilibrium of the retarding and accelerating forces was established and long continued. With the final cessation of the fires, and with the favoring conditions incident to agricultural occupancy, that equilibrium was destroyed, and the vigorous natural tendency to forest-distribution again asserted itself. It is now in full force except where it is checked by human agency; and it is greatly accelerated where such agency is exerted in its favor. It therefore only remains for the inhabitants of the great prairie region to decide whether their land shall be forested or treeless.

C. A. WHITE.

THE APPLICATION OF PHOTOGRAPHY TO THE PRODUCTION OF NATURAL HISTORY FIGURES.¹

FROM the accuracy and rapidity of its delineations, photography has proved itself an invaluable aid to science, although in natural history its use has been somewhat limited from the difficulty or impossibility of putting many of the objects in a vertical position. To make photography applicable to all classes of objects, it is simply necessary to have the camera so arranged that it may be placed at any angle from horizontal to vertical. The object to be photographed may then occupy its natural position, whatever that may be. For the last ten years, there has been in constant use, in the anatomical department of Cornell university, an apparatus constructed on this principle. It consists essentially of a camera fastened to a board that may be swung from horizontal to vertical, and clamped firmly at any angle.

With this instrument have been photographed, not only objects ordinarily photographed with a vertical or horizontal camera, but delicate embryo brains and other objects that would collapse if removed from liquid. Living salamanders (*Necturi*) have been photographed under water, their gills remaining completely outspread.

¹ Papers on this subject were given by the writer at the meeting of the American association for the advancement of science in 1879, and at the meeting of the Society of naturalists of the eastern United States in 1883. The only other persons employing a vertical camera in photography, known to the writer, are Dr. Theo. Deecke of the State lunatic-asylum at Utica, N.Y., and Dr. Darnaudieu of Lyons, France. (For the last, see *Anthony's Photographic bulletin*, December, 1883, p. 404.)

A photograph answers the requirements of a scientific figure in but few cases; as the object usually is to bring out with diagrammatic clearness a few details, subordinating or omitting others: hence the photograph is used as the basis of the figure; that is, the object is delineated of the desired size, all the parts being in their proper relative position. From this photographic picture may be traced all the outlines directly upon the drawing-paper; thus avoiding the tedious labor of measurement by

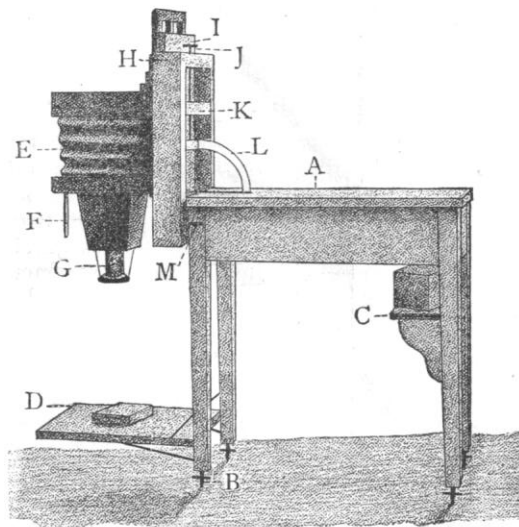


FIG. 1. — Side view of a vertical camera. *A*, the table supporting the camera; *B*, levelling-screws; *C*, shelf for holding a box of sand as counterpoise; *D*, stage upon which the object is placed (it is made parallel with the top of the table); *E*, camera with cone; *F*, slotted brass guide (see fig. 2); *G*, the photographic objective (its cap is made of card-board, and covered with black velvet); it is held in position by two rubber bands; *H*, frame hinged to the table, and supporting the camera; *I*, movable board to which the camera is clamped; *J*, head of the focusing-screw; *K*, block fastened to the movable board; *L*, and containing the nut which receives the focusing-screw; *L*, semicircle by which the frame bearing the camera is set at any angle; *M*, thumb-screw pressing against the semicircle *L*, and serving to fix it at any point.

the artist, and leaving all of his time available for artistic work proper.

While, however, the use of the photograph for outlines diminishes the labor of the artist about one-half, it increases that of the preparator; and herein lies one of its chief merits. The photographs being exact images of the preparations, the tendency will be to make them with greater care and delicacy, and the result will be less imagination and more reality in published scientific figures; and the objects prepared with such care will be preserved for future reference.

In the use of photography for figures, several considerations arise: 1°. The avoidance of distortion; 2°. The adjustment of the camera to

obtain an image of the desired size and focusing; 3°. Lighting and centring the object; 4°. The obtaining of outlines for tracing upon the drawing-paper.

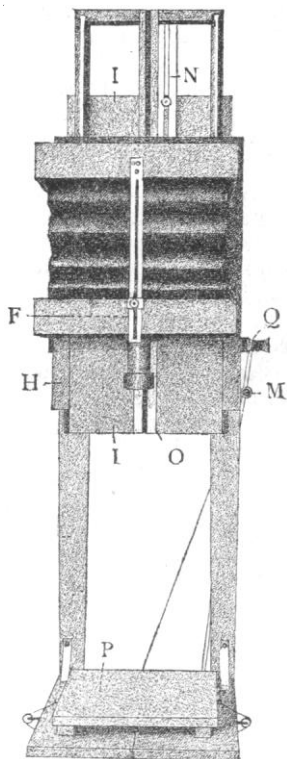


FIG. 2. — Front view of the vertical camera. *F*, slotted brass guide, serving to support the upper part of the camera, and to indicate the enlargement or reduction; *H*, frame hinged to the table; *I*, board moving in the frame *H*, and holding the camera; *N*, iron bars attached to the bed of the camera (upon these presses the thumb-screw from the board *J*); *O*, similar iron bars in the movable board (in the slot works a thumb-screw from the camera; these thumb-screws clamp the camera to the movable board); *P*, object-carrier on casters (this may be moved by the operator by turning the spools *Q*); *Q*, spools for the cords from the object-carrier.

1°. While the camera delineates rapidly, the image is liable to distortion. I believe opticians are agreed, that, in order to obtain correct photographic images, the objective must be properly made, and the plane of the object must be parallel to the plane of the ground glass. Furthermore, as most of the objects in natural history have not plain surfaces, but are situated in several planes at different levels, there will be a liability of distortion from that cause also. This may be rendered practically nothing, however, by using in the objective a diaphragm with a small opening.

2°. By placing the camera on a long table, and a scale of some kind against the wall, the exact position of the ground glass for various

sizes may be determined once for all. These positions are noted in some way (on the brass guide, *F*, in the apparatus here figured). Whenever it is desired to photograph an object, natural size, for example, the ground glass is fixed in the proper position indicated on the brass guide (fig. 2, *F*). Then, as the relative position of the objective and the ground glass cannot be varied, it is necessary, in focusing, to move the camera toward or away from the object, or the reverse. In order to do this, the camera is fastened to a board which moves in a frame by means of a screw (figs. 1, 2, *I*, *H*, *J*). Whenever the camera is to be moved considerably, — as to a position for twice natural size from one giving an image of half natural size, — the position of the camera on the board is changed by loosening the two thumb-screws clamping it to the movable board (fig. 2, *N*, *O*). The approximate position for the various sizes being once determined and noted, it is but a moment's work to set the camera for any enlargement or reduction within its range.

3°. The object is placed on the horizontal stage, and so arranged that the lighting will give prominence to the parts to be especially emphasized. For a contrasting background, black velveteen for light, and white paper for dark, objects, have been found excellent. To get the object in the centre of the field of the objective, the stage bearing the object may be movable; so that the operator, while looking at the image on the ground glass, may move the object in any desired direction by turning the spools on which are wound the cords from the movable stage (fig. 2).

4°. If the photographic prints are to be used solely for outlines, the well-known blue prints so much used in engineering and architecture may be made. If, however, light and shade and fine details are to be brought out with great distinctness, either a silver or a platinotype print is preferable. In whatever way the print is made, it is blacked on the back with soft lead-pencil, put over the drawing-paper, and the outlines traced. Instead of making a print from the negative, one may get a tracing directly from it on tracing-paper; and this may, of course, be used in the usual way. Finally, if one possesses a camera, a tracing may be made of the image directly, without the aid of a negative. It is only necessary to substitute a piece of plain glass for the ground glass, and, after spreading upon it some fine tracing-paper, to trace the image. This is especially applicable to the enlargement or reduction of other figures.

SIMON H. GAGE.